Section 7.0 Best Management Practices - Costs

This section provides a summary of the Best Management Practice (BMP) cost information obtained during the preparation of this document. Although not specifically requested, a significant amount of BMP cost information was obtained. This information should provide mine engineers and permitters with at least preliminary or "ballpark" costs for the BMPs. This cost information should not preclude detailed engineering analysis and design efforts to include such things as location, climate, and site limitations.

When sufficient data were available, a least-squares-best-fit linear regression was done on the data to come up with a cost equation. When limited data were available unit costs were developed and presented.

The primary source of information used in the preparation of this section was 61 data packages gathered from six states and representing remining or reclamation activities during which these BMPs were implemented (Appendix A: EPA Remining Database). A limited amount of cost information was found in the literature. Abatement plans from several state's mining permit applications require the applicant to define which BMPs will be used to abate or ameliorate pollutional discharges, and estimate what the BMP implementation cost would be. This cost information has been summarized in this Section in table form. Very little has been done with the cost information other than indexing to today's dollars with the aid of the Engineering News Record (ENR) Construction Cost Index (ENR, 1999).

Unless otherwise noted, the costs were considered current with the date of permit application and have been indexed to January 1999 dollars with the use of ENR's Construction Cost Index. January 1999 has an ENR index value of 6000. For example, the index for September 1995 is 5491. Dividing the January 1999 index by the September 1995 index yields a factor of 1.09. Costs in September 1995 were multiplied by this factor to derive costs in January 1999 dollars.

The cost information has been summarized alphabetically by BMP. Within each BMP the cost information is summarized by mine followed by assumptions underlying the costs, and finally, cost equations generated from the available cost information (if possible). Cost information for the following BMPs are summarized in the following tables:

Table 7a: Alkaline Addition

Mine	Acres	Alkaline Material (tons/acre)	Location	Alkaline Addition Cost ($/ton)	Cost (Date)	Unit Cost ENR 6000 ($/ton)
Lime Addition						
PA (10)	28.6	3	Spoil	$ 17.50	$1,501 (2/90)	$ 22.40
PA(1)	26.1	30	Pit Floor	$ 16.85[2]	$13,194 (3/90)	$ 21.55
PA(11)	61.3	50	Pit Floor	$ 6.00	$18,390 (9/89)	$ 7.73
PA (8)	22.68	403-493	Blast Holes, & Pit Floor	$ 5.00[3]	$68,040 (2/93)	NA
PA (19)	9.8	1050	NA	$ 10.00	$102,900(12/97)	$ 10.24
Ash Addition						
PA (2)	50[1]				$2,608,000(8/88)	$ 2.55

NA = Not Available.
[1] Ash and refuse will be placed in alternating two foot lifts, reconstructed pile estimated to contain 1,650,000 tons of refuse and 1,350,000 tons of ash.
[2] Cost includes $2.25/ton handling, $6.00/ton trucking, and $8.60/ton lime.
[3] Cost includes $1.00/ton handling, $1.00/ton trucking, and $3.00/ton lime.

Assumptions:

- Costs include lime, trucking, and spreading.

Cost Equation: Not developed.

Table 7b: Anoxic Limestone Drains (ALDs)

Mine	Design Flow (gpm)	Loss of Limestone (mg/L)	Design Life (Years)	Design Loading (tons $CaCO_3$/gal·min)	Cost (Date)	Unit Cost ENR 6000 ($/Ton of Limestone)
TN (3)	8	250	40	33	NA	NA
TN (5)	160	250	30	20[1]	$ 90,014 (5/94)	$ 31.42
TN (2)	200	370	10	20	$ 230,000[2] (1995)	NA

NA = Not Available.
[1] Design loading required 4,000 tons of limestone; 5,000 actually used to provide safety factor.
[2] Costs are for a 5,000 ton ALD and a 2.35 acre oxidation pond.

Assumptions:

- TN(2) - 5,000 tons of limestone used; loss of limestone 370 mg/L; design life 10 years.
- TN(3) - 264 tons of limestone used; loss of limestone 250 mg/L; design life 40 years; safety factor 1.5.
- TN(5) - 3,180 tons of limestone used; loss of limestone 250 mg/L; design life 30 years; safety factor 1.2.

Cost Equation: Not developed, only one point available.

Table 7c: Ash Fill Placement

Mine	Cubic Yards	Cost ($/cu. Yd.)	Cost (Date)	Unit Cost ENR 6000 ($/ cu.yd.)
PA (18)	15,000,000	$ 0.25	$ 3,750,000 (12/96)	$ 0.26

Assumptions:

- Cost are for handling ash only (hauling, spreading, and compacting)

Cost Equation: Not developed, only one point available.

Table 7d: Bactericides

Mine	Acres	Cost/Acre	Cost (Date)	Unit Cost ENR 6000 ($/acre)
PA (10)	13.0	$ 2,100	$ 27,300 (2/90)	$ 2,689

Assumptions:

- Use B.F. Goodrich's "ProMac"
- Applied before top cover is spread and revegetated

Cost Equation: Not developed, only one point available.

Table 7e: Check Dams

Source			Cost (Date)	Cost ENR 6000
Ref. (USEPA, 1992)				See Below

Assumptions:

- Check dams are appropriate for use in the following locations:
  1. Across swales or drainage ditches to reduce the velocity of flow.
  2. Where velocity should be reduced because a vegetated channel lining has not yet been established.
- Check dams may never be used in a live stream unless approved by the appropriate government agency.
- The drainage area above the check dam should be between 2 and 10 acres.
- The dams should be spaced so that the toe of the upstream dam is never any higher than the top of the downstream dam.
- The center of the dam must be 6 inches to 9 inches lower than either edge, and the maximum height of the dam should be 24 inches.
- The check dam should be as much as 18 inches wider than the banks of the channel to prevent undercutting as overland flow water re-enters the channel.
- Excavating a sump immediately upstream from the check dam improves its effectiveness.
- Provide outlet stabilization below the lowest check dam where the risk of erosion is greatest.
- Consider the use of channel linings or protection such as plastic sheeting or rip rap where there may be significant erosion or prolonged submergence.

Cost Equation:
The costs for the construction of check dams varies with the material used. Rock costs about $100 per dam ($ 119 => ENR = 6000). Log check dams are usually slightly less expensive than rock check dams. All costs vary depending on the width of the channel to be checked.

Table 7f: Constructed Wetlands

Mine	Fe Loading (gr/day/m^2)	Mn Loading (gr/day/m^2)	Ox. Pond (acres)	Marsh (acres)	Total Acres (acres)	Cost (Date)	Cost ENR 6000 ($1,000)
TN (5)[1]	20	0.5	0.76[2]	2.69	3.45	$ 21,559 (5/94)	$ 23.93
VA (8)			14.2		14.2	$ 284,000 (9/96)	$ 299.84
TN (2)	17.2		2.35[3]	2.0	4.35	$ 21,000[4]	$ 23.03

NA = Not Available

[1] This wetlands design includes areas for an oxidation pond and marshes in the calculation for required area of wetland. Oxidation pond designed for 24 hours retention at 160 gpm and 5 foot depth of 6,160 sq. ft. (Actually used 33,450 sq. ft. At 6 ft. depth). The remainder of the wetland will be marsh (150,790 sq.ft. - 33,450 sq.ft = 117,340 sq.ft.).

[2] Twenty-four hour retention minimum.

[3] Minimum 1 to 2 days retention; 11.0 actual.

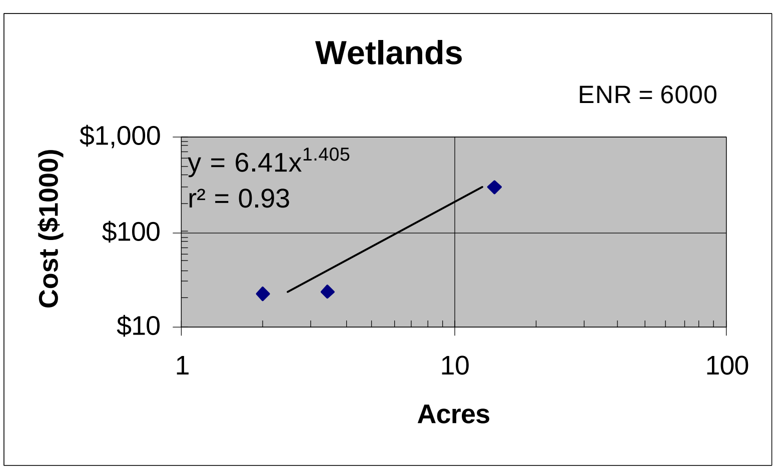
[4] Costs are for the 2.0 acre marsh area only.

Assumptions:

- Refer to design criteria in table above.

Cost Equation:

Least Squares Best Fit Linear Regression expressed as $y = ax^b$, (ENR = 6000):



Equation:

$$y = 6.41x^{1.405}$$

where: x = acres
y = Cost ($1,000)
n = 3
$r^2 = 0.93$

Table 7g: Daylighting

Mine	Acres Daylighted	Recoverable Coal (1,000 tons)	Cost/Ton of Recovered Coal	Cost (Date)	Cost ENR 6000 ($1,000)
PA (6)	5.0	9.72	$ 0.25	$ 2,430 (9/89)	$ 3.13
PA (1)	3.6	8.957	$ 1.21	$ 10,880 (4/90)	$ 13.91
PA (7)	15.1	26.550	$ 1.54	$ 40,770 (10/89)	$ 52.52
PA (11)	23.7	47.988	$ 1.67	$79,988 (10/93)	$ 91.17
PA (9)	103.5	229.767	$ 2.00	$ 459,534 (8/94)	$ 508.33
PA (3)	90	550.785	$ 1.21	$ 666,450 (12/88)	$ 875.37

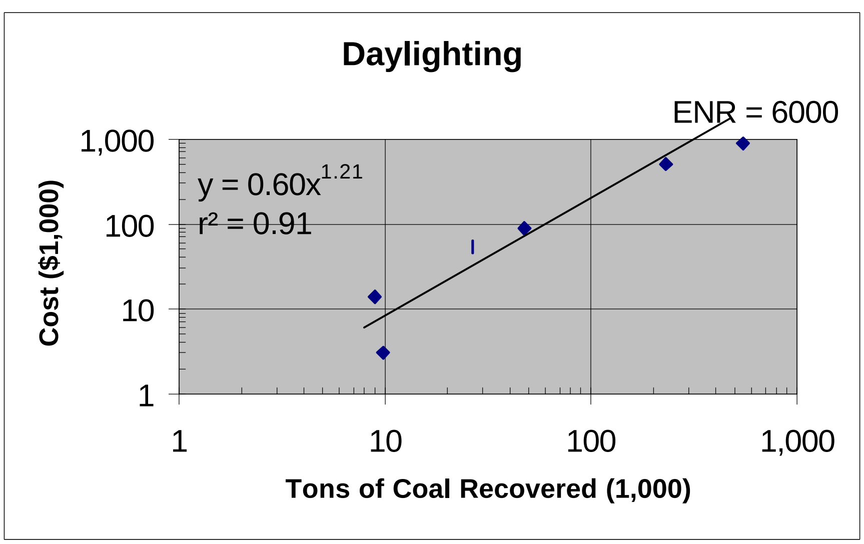
[1] Complete.
[2] Partial.

Assumptions:

- Mining ratio cannot exceed 18:1 or 60 ft max. Highwall
- 60 ft. Max. Highwall

Cost Equation:
Least Squares Best Fit Linear Regression expressed as $y = ax^b$, (ENR=6000):

Equation:



$y = 0.60x^{1.21}$

where: x = Tons of Recov. Coal (1,000)

y = Cost ($1,000)

n = 6
$r^2 = 0.91$

Table 7h: Diversion Ditch

Mine	Length (Ft.)	Design Flow (cfs)	Cost (Date)	Cost ENR 6000	Unit Cost ENR 6000 ($/Ft.)
TN (5)	875[1]	195	$ 7,925 (5/94)	$ 8,797	$10.05

[1] Estimated.

Assumptions:

- Bottom Width 20'
- Side Slopes 2H:1V
- Ditch Slope 1%
- Constructed Depth 3'
- Flow Depth (Design) 1.85'
- Lining Rip rap for a 2.25' flow depth

Cost Equation: Not developed, only one point available.

Table 7i: Diversion Wells, Alkalinity Producing

Reference	Materials	Labor	Total Cost ENR 6000
McClintock, 1993	$ 5,000	$ 6,000	$ 11,000 ea.

Assumptions:

- From page ten of the reference: "A rough estimate is about $5,000 for the materials and equipment rental."
- From page 7 of the reference;" About 8 to 10 people working 8 hour per day for 2 to 3 days are needed for construction of a diversion well."
  (10 people x 8 hours/day x 3 days x $ 25.00/hr = $ 6,000)

Cost Equation: Not developed, only one point available.

Table 7j: Drains, Pit Floor

Mine	Total Length (Ft.)	Cost (Date)	Unit Cost ENR 6000 ($/Ft.)
PA (8)	2,600	$ 132,500 (2/93)	$ 60.31

Assumptions:

- Details not available in permit file.

Cost Equation: Not developed, only one point available.

Table 7k: Regrading of Abandoned Mine Spoil/Highwalls

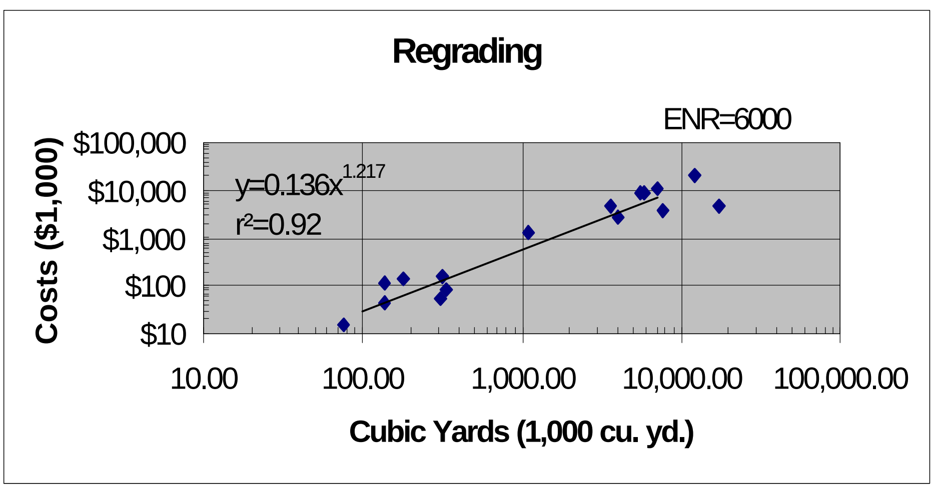
Mine	Cubic Yards (1,000)	Cost/cu.yd.	Cost (Date)	Cost ENR 6000 ($ 1,000)
PA(7)	76.550	$ 0.16	$ 12,060 (10/89)	$ 15.545
PA (10)	138.905	$ 0.25	$ 34,171 (2/90)	$ 43.76
PA (11)	304.944	$ 0.16	$ 48,150 (10/93)	$ 54.88
KY (4)	332.046	$ 0.23	$ 76,039 (9/94)	$ 83.91
PA (6)	136.660	$0.65	$ 88,829 (9/89)	$ 114.42
PA (5)	178.100	$ 0.75	$ 133,575 (9/94)	$ 147.76
PA (19)	321.376	$ 0.50	$ 160,688 (12/97)	$ 164.58
PA (3)	1,090.613	$ 0.90	$ 981,552 (12/88)	$ 1,289.25
PA (18)	4,000	$ 0.65	$ 2,600,000 (9/97)	$ 2,666.21
PA (9)	7,743	$ 0.45	$ 3,484,350 (8/94)	$ 3,854.37
WV (4)	3,630	$ 1.00	$ 3,630,000 (2/90)	$ 4,648.88
KY (3)	17,250.378	$ 0.23	$ 3,950,378 (8/91)	$ 4,845.11
WV (9)	5,488.314	$ 1.00	$ 5,488,314 (10/81)	$ 8,997.24
WV (7)	5,848	$ 1.00	$ 5,848,000 (9/83)	$ 8,471.27
WV (10)	7,139	$ 1.00	$ 7,139,000 (3/85)	$ 10,318.96
WV (2)	12,100	$ 1.00	$ 12,100,000 (1981)	$ 20,537.48

Assumptions:

- Regrading of abandoned mine spoil
- Elimination of abandoned highwalls

Cost Equation:

Least Squares Best Fit Linear Regression expressed as $y = ax^b$, (ENR=6000):



Equation:

$y=0.136x^{1.217}$

where: x = Cu.Yds. (1,000)
y = Cost ($1,000)

n = 16
$r^2 = 0.92$

Table 7l: Revegetation

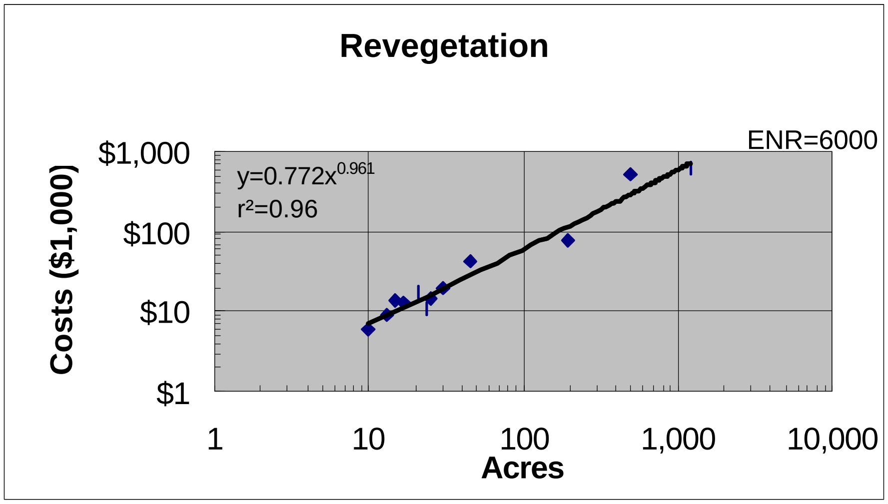
Mine	Acres	Cost/Acre	Cost (Date)	Cost ENR 6000 ($ 1,000)
PA (7)	10	$ 450	$ 4,500 (10/89)	$ 5.80
PA (10)	13	$ 550	$ 7,150 (2/90)	$ 9.16
KY (4)	23.4	$ 409	$ 9,570 (9/94)	$10.56
PA (6)	17	$ 600	$ 10,200 (9/89)	$ 13.14
VA (6)	15	$ 750	$ 11,250 (10/91)	$ 13.80
PA(11)	25.2	$ 450	$ 11,340 (9/89)	$ 14.61
PA (8)	21	$ 720	$ 16,200 (12/94)	$ 17.87
PA (19)	30.3	$ 650	$ 19,695 (12/97)	$ 20.17
PA (4)	45	$ 800	$ 36,000 (2/93)	$ 42.60
KY (1)	195.7	$ 625	$ 69,264 (7/97)	$ 69.60
PA (18)	500	$ 1,000	$ 500,000 (9/97)	$ 512.73
KY (3)	1,215.7	$ 409	$ 497,221 (8/91)	$ 609.84

Assumptions:

- Lime
- Fertilizer
- Seed
- Mulch
- Handling and spreading of above.

Cost Equation:

Least Squares Best Fit Linear Regression expressed as $y = ax^b$, (ENR=6000).



Equation:

$y = 0.772x^{0.961}$

where: x = Acres
y = Cost ($1,000)

$r^2 = 0.96$
n = 12

Table 7m: Sealing and Rerouting of Mine Water from Abandoned Workings

Mine	Lin. Ft. (1000)	Cost/ Lin. Ft.	Clay (Cu. Yd.)	Cost/ Cu. Yd.	Cost (Date)	Cost ENR 6000 ($ 1,000)
Highwall Seal						
PA (1)	1.75	$ 4.69	4,111	$ 2.00	$ 8,222 (3/90)	$ 10.52
PA(3)	10.50	$ 3.80	20,000	$ 2.00	$ 40,000 (12/88)	$ 52.54
Clay Barrier						
PA (10)	1.75	$ 0.67	583	$ 2.00	$ 1,166 (9/96)	$ 1.23
Auger Holes						
KY (4)	1.88	$ 0.20	1,671	$ 0.23	$ 380 (9/94)	$ 0.42
KY (3)	11.16	$ 0.20	9,920	$ 0.23	$ 2,275 (8/91)	$ 2.79

Assumptions:

Highwall Seal
- 10' - 12' at base
- 8' high
- slope away from highwall face
- Mine void to be filled with clay to a width and depth of a minimum of 3 times the diameter of the exposed opening.
- Clay available on-site.

Clay Barrier
- 3' high
- 3' wide
- Clay available on-site

Auger Hole Seals
- 4' high
- 6' wide
- Clay available on-site

Cost Equations:

Least Squares Best Fit Linear Regression expressed as $y = ax^b$, (ENR=6000):

Highwall Seal ==> $y = 6.37x^{0.90}$ where: x = Linear Feet (1,000) $r^2 = 1.0$
y = Cost ($1,000) n = 2

Clay Barrier ==> $y = 0.703x^{1.0}$ where: x = Linear Feet (1,000)
y = Cost ($1,000)

Auger Hole Seal ==> $y = 0.215x^{1.06}$ where: x = Linear Feet (1,000) $r^2 = 1.0$
y = Cost ($1,000) n = 2

Table 7n: Silt Fences

Source		**Unit Cost (Date)**	**Unit Cost ENR 6000 ($/Ft.)**
Ref.(USEPA, 1992)		$ 6.00/Ft. (1992)	$ 7.22[1]

[1] Installation costs only.

Assumptions:

- Silt fences are appropriate at the following general locations:
  (1) Immediately upstream of point(s) of runoff discharge from a site before flow becomes concentrated (maximum design flow rate should not exceed 0.5 cubic feet per second).
  (2) Below disturbed areas where runoff may occur in the form of overland flow.
- Ponding should not be allowed behind silt fences since they will collapse under high pressure; the design should provide sufficient outlets to prevent overtopping.
- The drainage area should not exceed 0.25 acre per 100 feet of fence length.
- For slopes between 50:1 and 5:1, the maximum allowable upstream flow path length to the fence is 100 feet; for slopes 2:1 and steeper, the maximum is 20 feet.
- The maximum up slope grade perpendicular to the fence line should not exceed 1:1.
- Synthetic silt fences should be designed for six months of service; burlap is only acceptable for periods of up to 60 days.

Cost Equation: Not developed with only one point available.

Table 7o: Special Handling for Toxic and Acid Forming Materials

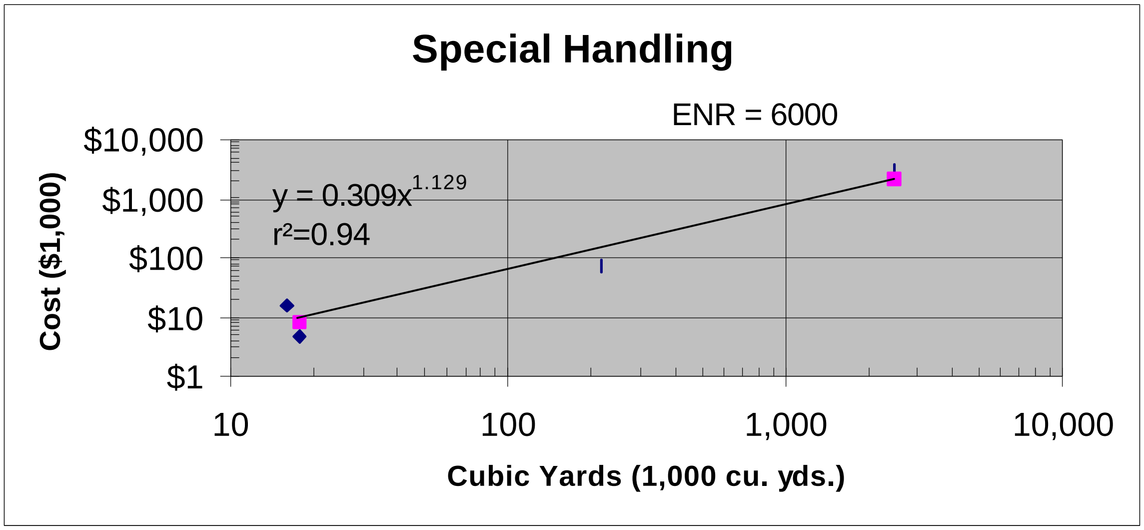
Mine	Cubic Yards (1,000)	Cost/cu.yd.	Cost (Date)	Cost ENR 6000 ($ 1,000)
PA (11)	17.58	$ 0.20	$ 3,516 (9/89)	$ 4.53
PA (19)	15.81	$ 1.00	$ 15,811 (12/97)	$16.19
PA (7)	216.13	$ 0.25	$ 54,032 (6/88)	$ 71.64
PA (3)	2,468.4	$ 0.90	$2,221,560 (12/88)	$2,917.99

Assumptions:

- Material placed 25' above floor
- Placed in 2' layers
- Up to 30" clean fill in between
- 25 tons/acre of lime on top
- 25' from outcrops
- 4' clean cover

Cost Equation:
Least Squares Best Fit Linear Regression expressed as $y = ax^b$, (ENR=6000):

$y = 0.309x^{1.129}$ where: x = Cubic Yards (1,000) $r^2 = 0.94$
y = Cost ($1,000) n = 4



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ENR, 1999. Engineering New Record Construction Cost Index (1908-1999). http://www.enr.com/cost/costcci.asp, 2 p.

McClintock, S.A., D.E. Arnold and A.J. Gaydos, 1993. An Installation and Operations Manual for Diversion Wells: A Low Cost Approach for Treatment of Acidic Streams. Pennsylvania State University, 23 p.

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